Using Bittorrent and SVC for Efficient Video Sharing and Streaming

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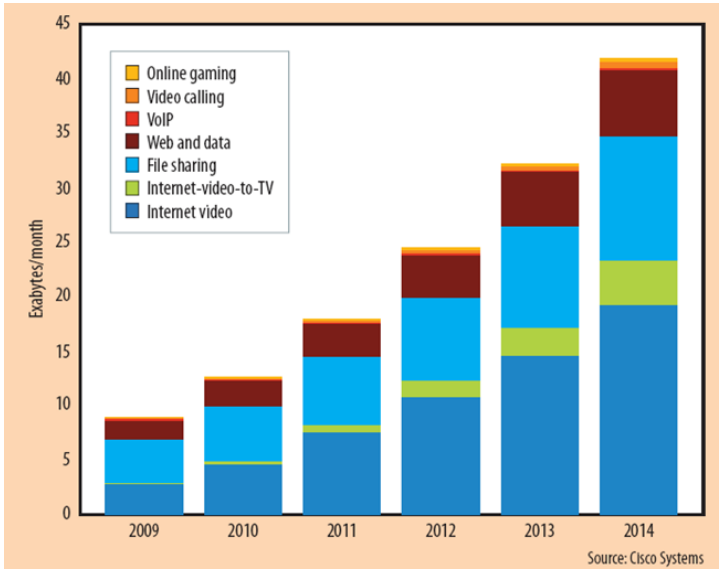
Outline

Internet video

Consumed Internet traffic in 2009	33.2%
Predicted ratio for the end of 2010	40%
Long term prediction: 2009-2014	7x increase
Youtube in 2007 (watched Internet videos)	60%
Youtube in 2007 (HTTP traffic/ Internet traffic)	20% / 10%

Internet video statistics [1][2][3]



Internet traffic statistics [1]

- Internet video (Vod, video-to-TV, etc) dominates the Internet traffic
- Significant portion of the Internet traffic = user generated video content (e.g. Youtube)

$\Rightarrow$**Develop efficient means to transport video over the Internet and help users to share them**

Internet video challenges

Internet not suitable to transport video

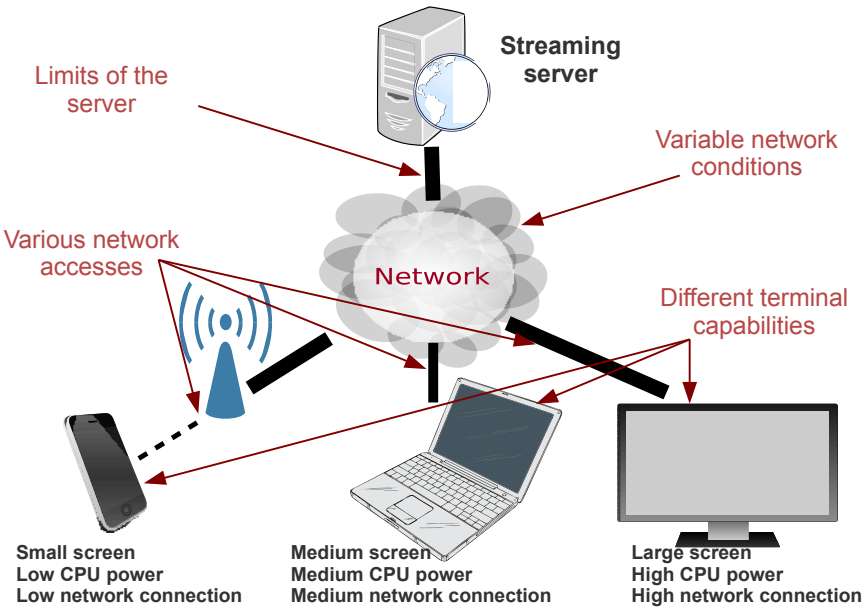
Video needs sustained network connection and may require large network bandwidth

Solutions

- Distributed system: Content Delivery Networks (CDNs), **Peer-to-Peer (P2P)**, and Cloud based streaming
- Adaptable video coding: **Scalable Video Coding (SVC)**, Multiple Description Coding (MDC), and Network Coding (NC)

$\Rightarrow$ **Extend the Bittorrent protocol to support SVC video streaming**

Internet video challenges



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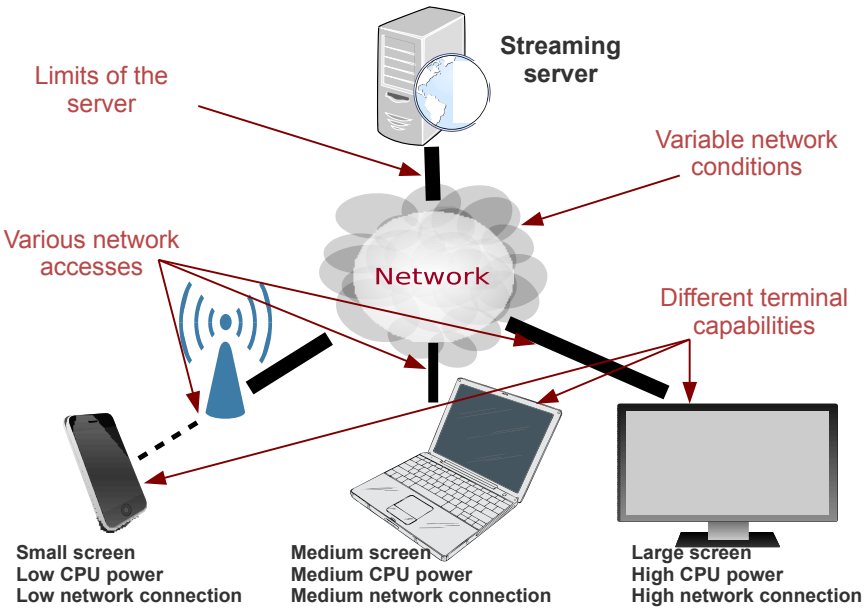

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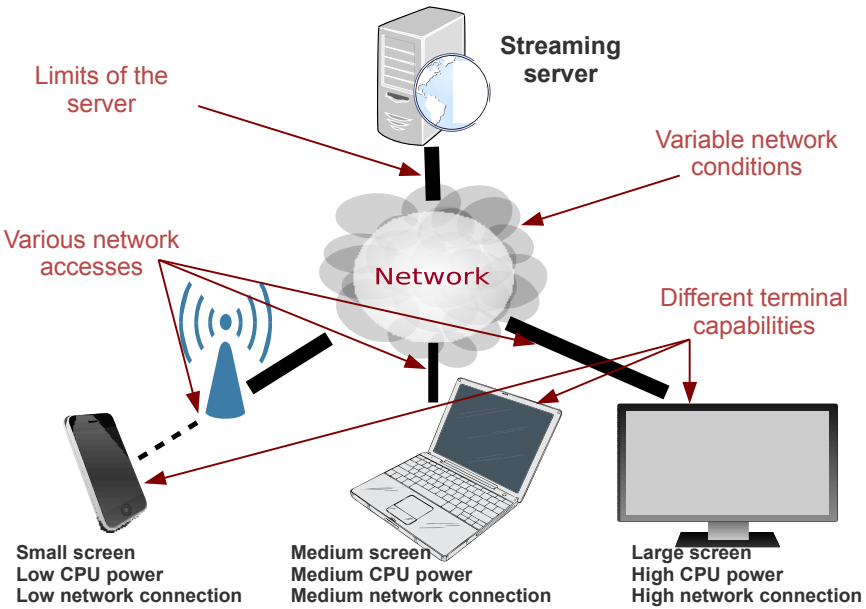

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Outline

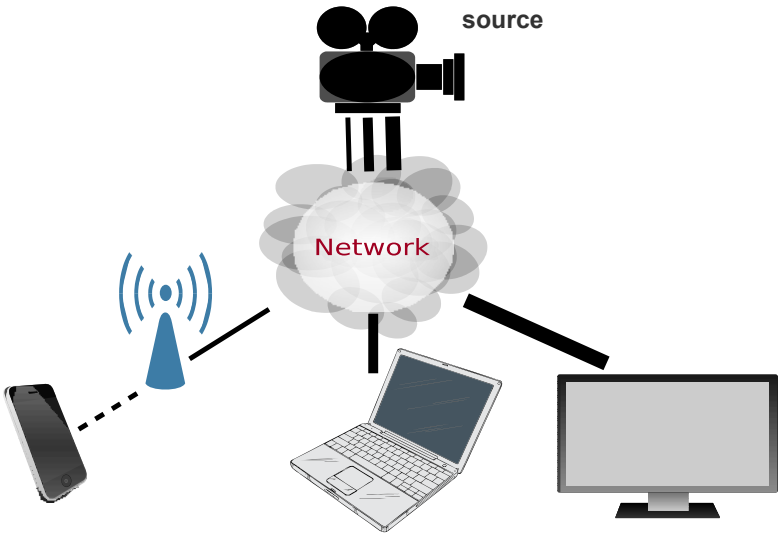
Scalable Video Coding [4]

Definition

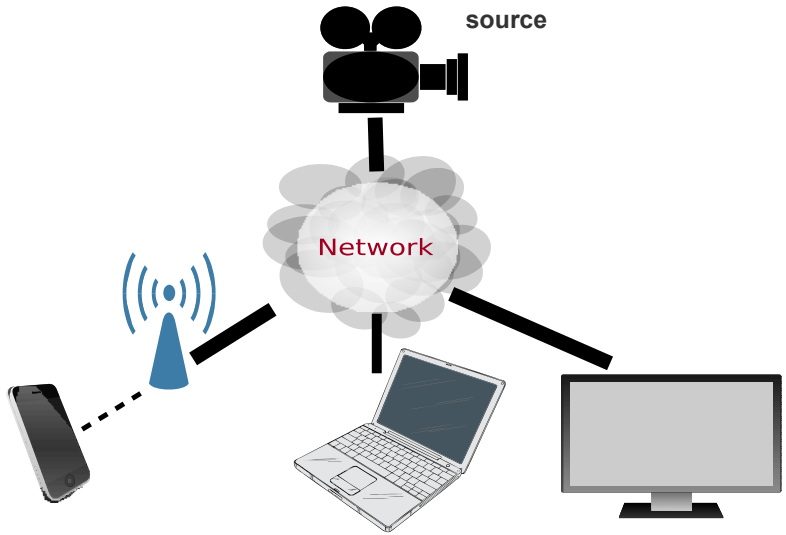
Encoding a single video stream that embeds multiple qualities

How?

- Single video stream = Multiple layers = Base layer + enhancement layers
- Extension of single-layer H.264/AVC standard $\Rightarrow$ High compression rate



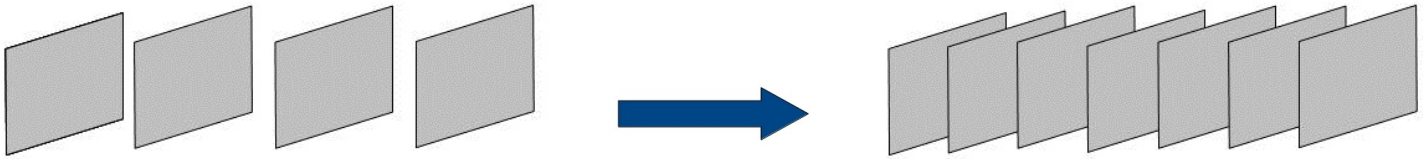
Single-layer simulcast



Multi-layer multicast

Types of Scalability

- Temporal scalability



- Spatial scalability

- Quality Scalability

SVC structure and streaming buffer

SVC stream structure

- $\{D_{max}, Q_{max}, T_{max}\}$ maximum spatial, quality and temporal level resp.
- $Stream = \{AU_i, i = 1..FrameMax\}$ is a set of Frames of Access Units (AUs)
- $AU = \{NAL_i, i = 1..D_{max} \times Q_{max}\}$ is a set Network Abstraction Layer (NAL) units
- $Stream = \{Layer_i, i = 1..D_{max} \times Q_{max} \times T_{max}\}$ is a set of Layers

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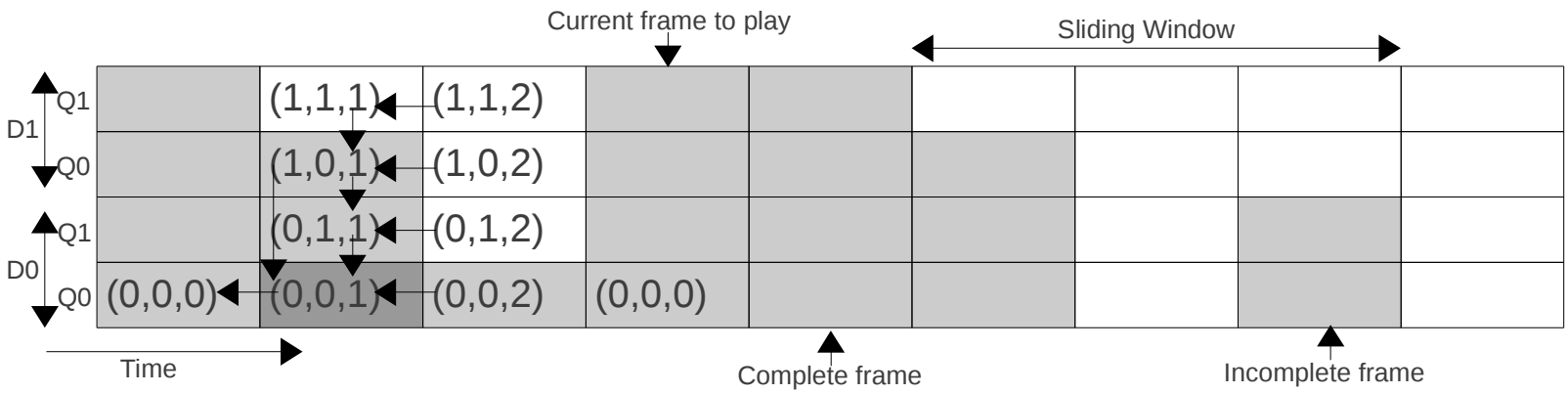


A sliding window's buffer snapshot: 2 spatial, 2 quality, 3 temporal levels ⇒ 12 layers

Outline

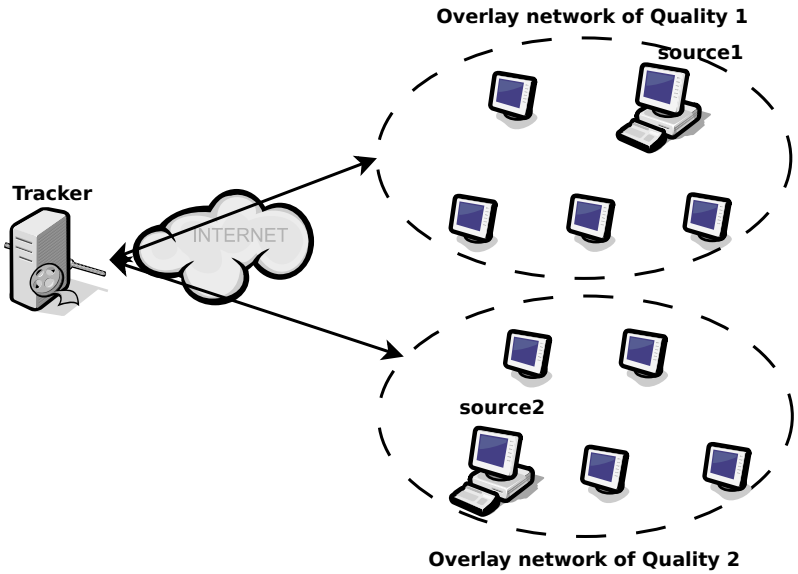
Bittorrent protocol [7]

- P2P file-sharing protocol

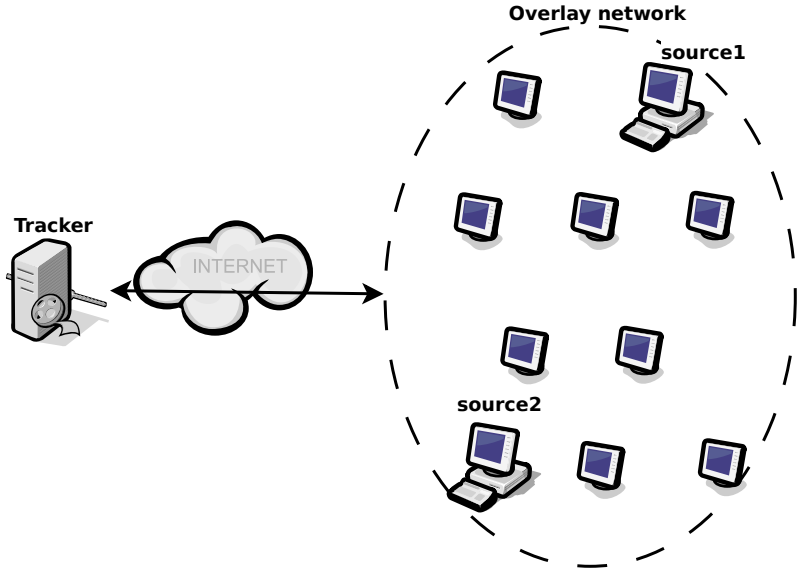
  - Entities
    - Tracker: central unit for peer discovery (random)
    - Seed: peer possessing the complete file
    - Leecher: peer downloading the file
  - Important algorithms:
    - Piece selection
      - File cut uniformly into pieces
      - Request strategies: random, rarest first
      - Piece download flow:
        $(\texttt{recv},\texttt{REQUEST},\texttt{send}) \Rightarrow (\texttt{send},\texttt{PIECE},\texttt{recv}) \Rightarrow (\texttt{recv},\texttt{HAVE},\texttt{All})$
    - Peer selection (choking/unchoking)
      - Tit-for-tat policy $\Rightarrow$ reciprocation
      - Based on download and upload rates
  - Simulation of the protocol: Omnet++ [5], **NS-2 [6]**

Outline

SVC in Bittorrent



Single-layer scenario



Multi-layer scenario

Observation

In addition to stream adaptation, multi-layer SVC **increases the global availability of the content** $\Rightarrow$ Better P2P efficiency

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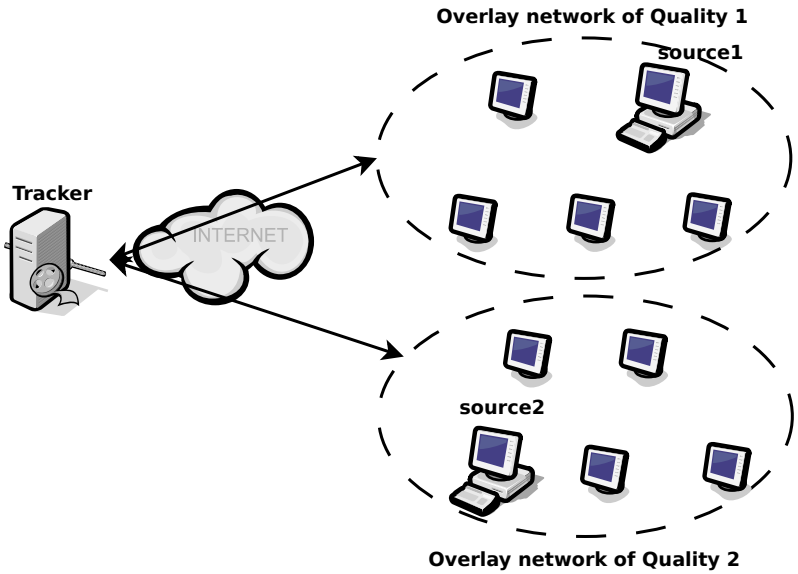

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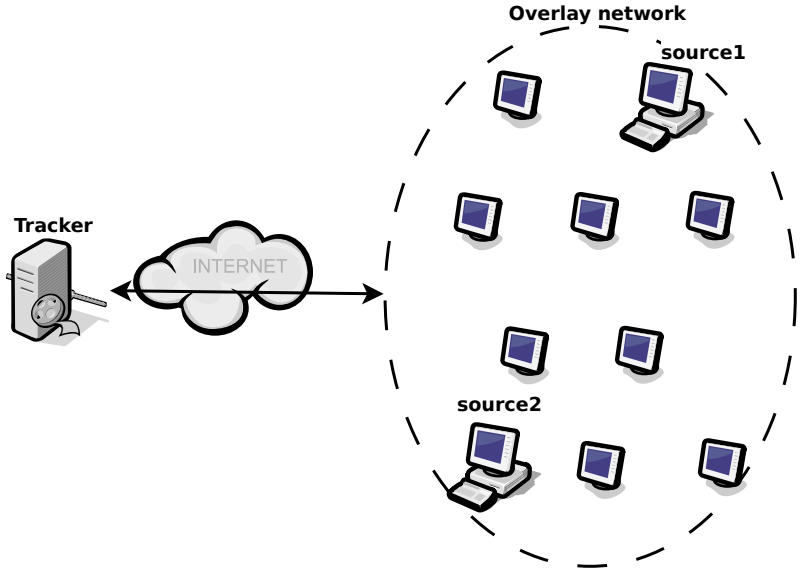

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Proposition: Change Bittorrent's piece selection algorithm

- Follow SVC structure: Basic request piece is a NAL unit (variable size)
  - Better adaptability of the stream. Can use RTP packetization [8]
  - Large overhead !! $\Rightarrow$ Multi-NAL unit requests [9]
- Fixed size sliding window [10]

Outline

Test environment

General configuration

Simulator	NS-2
Network topology	Star
Access Delay	Uniform[1,50] ms
Arrival	Flash crowd: uniform in choking interval
Departure	exp $\lambda = 1$

Video Encoding characteristics

Video sequence	Elephant dreams
Frame rate	24 frame/s
Spatial resolutions	QCIF (176x144) and CIF (352x288)
SNR Qualities	Q0 and Q1

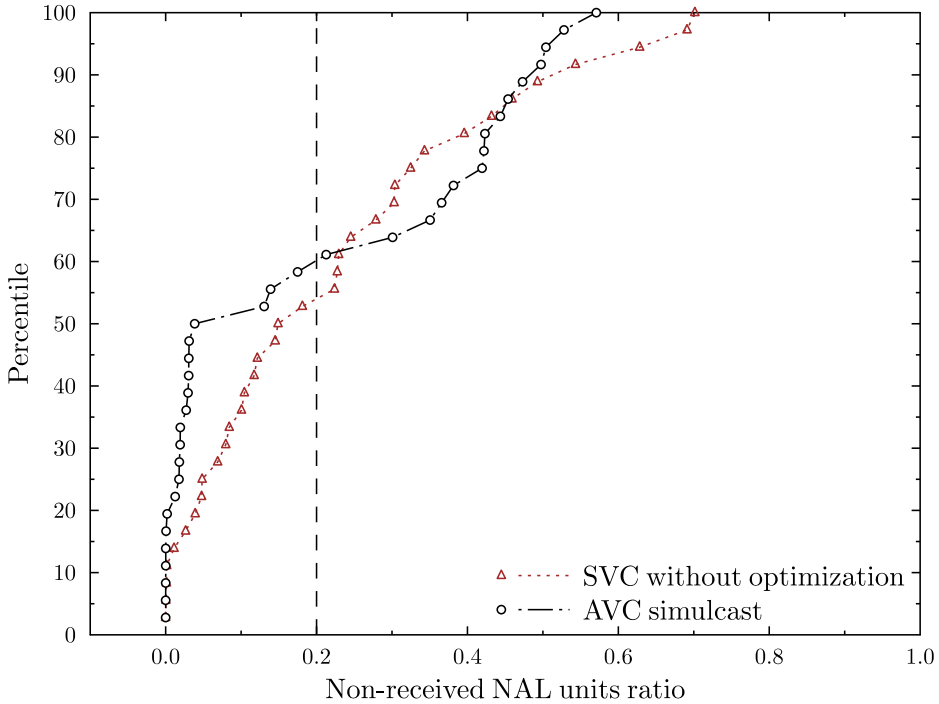
Peers characteristics and their distribution[11]

Total Upload BW (kbit/s)	256	320	384	448	512	640	768	1024	1500	3000
Contribute Up-BW(kbit/s)	150	250	300	350	400	500	600	800	1000	1000
Download BW (kbit/s)	512	640	768	1024	1300	2048	2048	3000	5000	9000
Distribution (%)	10.0	14.3	8.6	12.5	2.2	1.4	6.6	28.1	1.4	14.9

Seed and quality distribution

Down-bandwidth range (Kbps)	$<= 1024$	] 1024 , 2048]	] 2048 , 5000]	> 4000
Seed up-bandwidth (Kbps)	500	1000	1500	2000
Desired quality	QCIFxQ0	QCIFxQ1	CIFxQ0	CIFxQ1

Initial results: Comparison of SVC and AVC

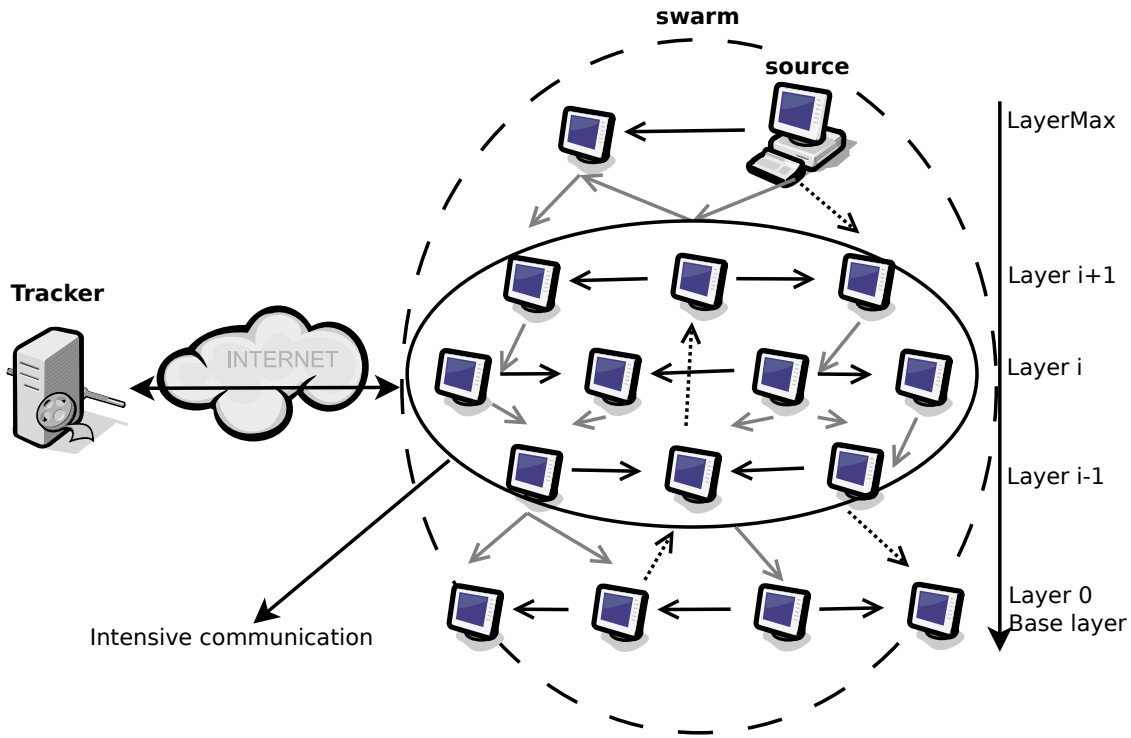


Distribution of 40 peers according to the amount of non-received data

Observation

Single-layer AVC offers a better QoS because there is a high reciprocation between the peers $\Rightarrow$ **Group the peers with close qualities** for high reciprocation and use the other peers to increase the download rate

Hierarchical overlay network organization



Hierarchical organization of the overlay network

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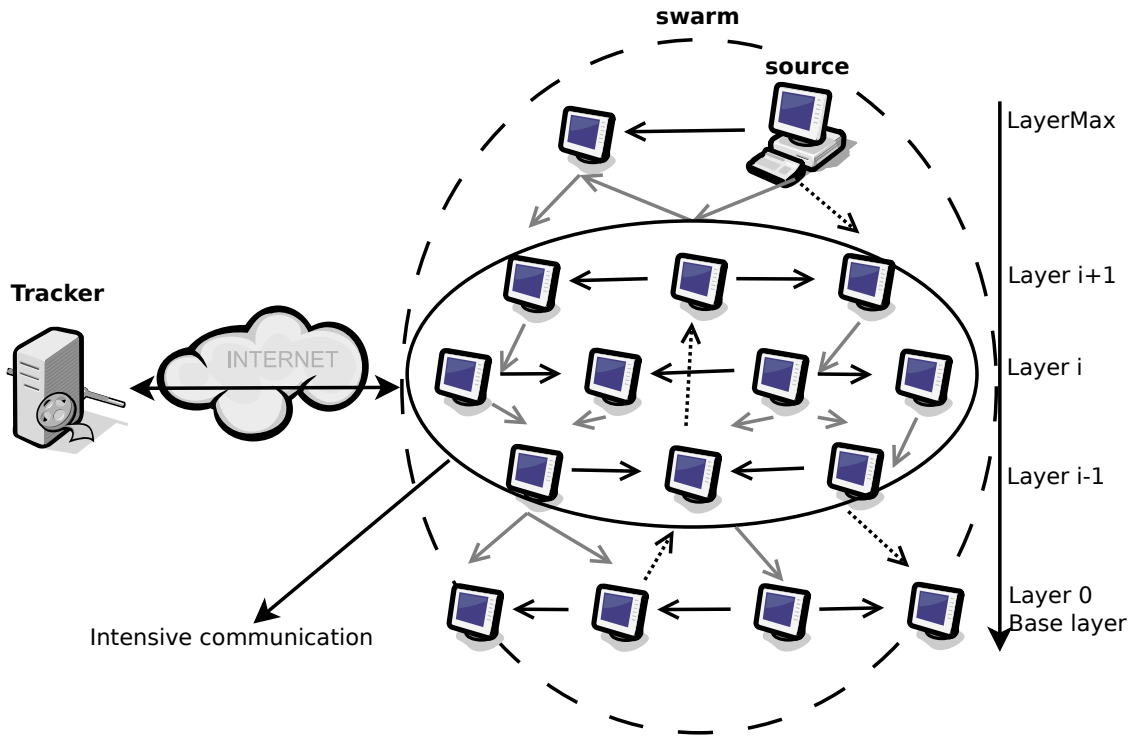


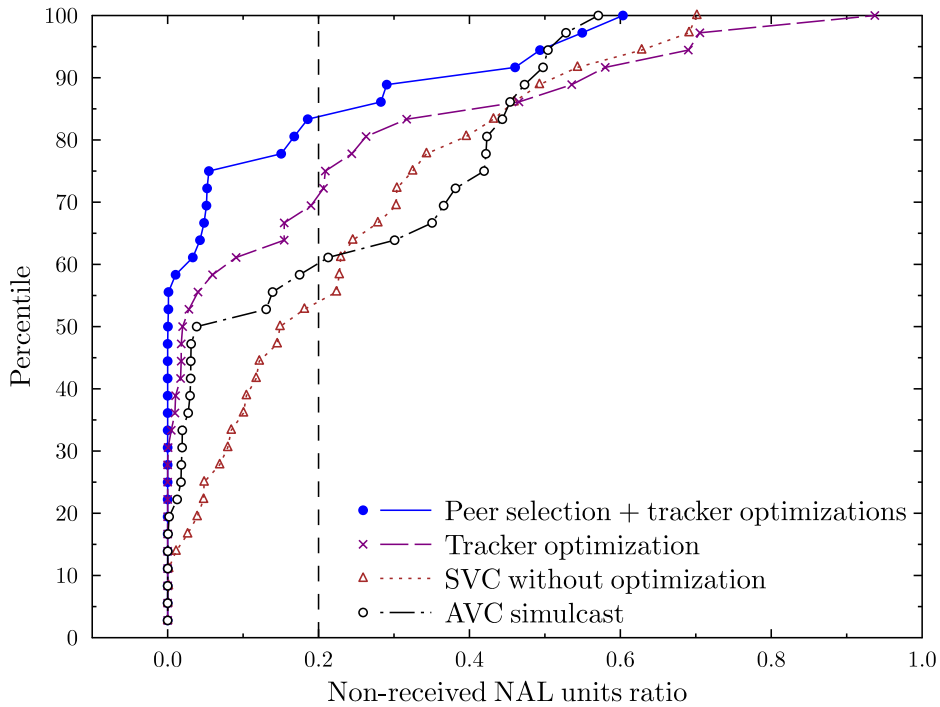
Hierarchical organization of the overlay network

How to reorganize the overlay in Bittorrent?

Changing the Bittorrent **tracker and peer selection** algorithms

- Tracker returns a more suitable peer list instead of a random one
- The client gives priority to closer quality peers when unchoking (without losing reciprocation)

New overlay organization results

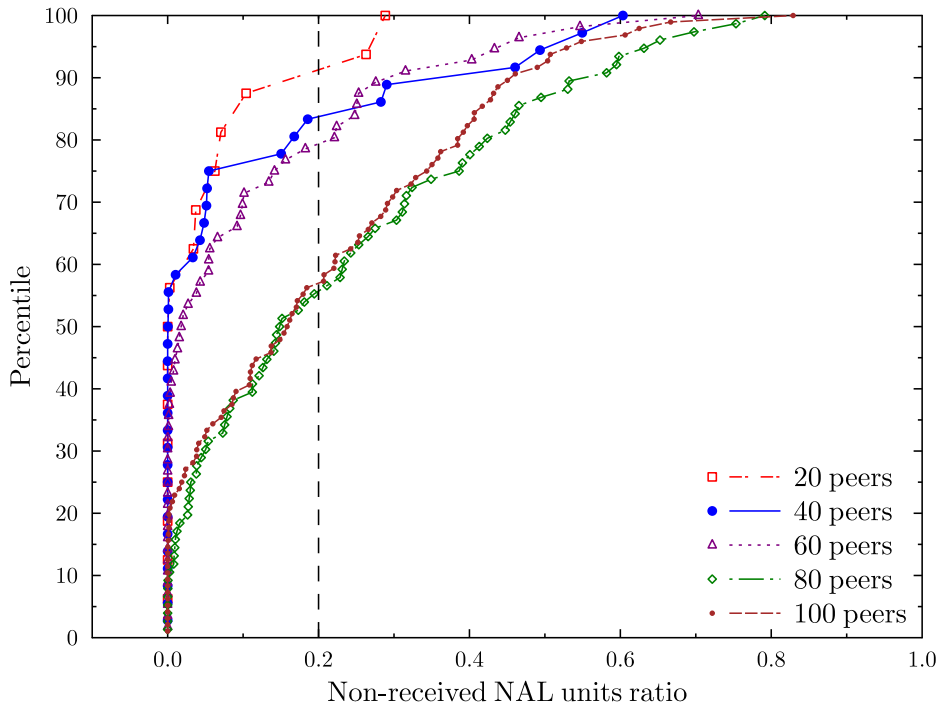


Distribution of 40 peers according to the amount of non-received data

Observation

New overlay organization for multi-layer SVC achieved higher quality and outperforms single-layer AVC

Scalability analysis

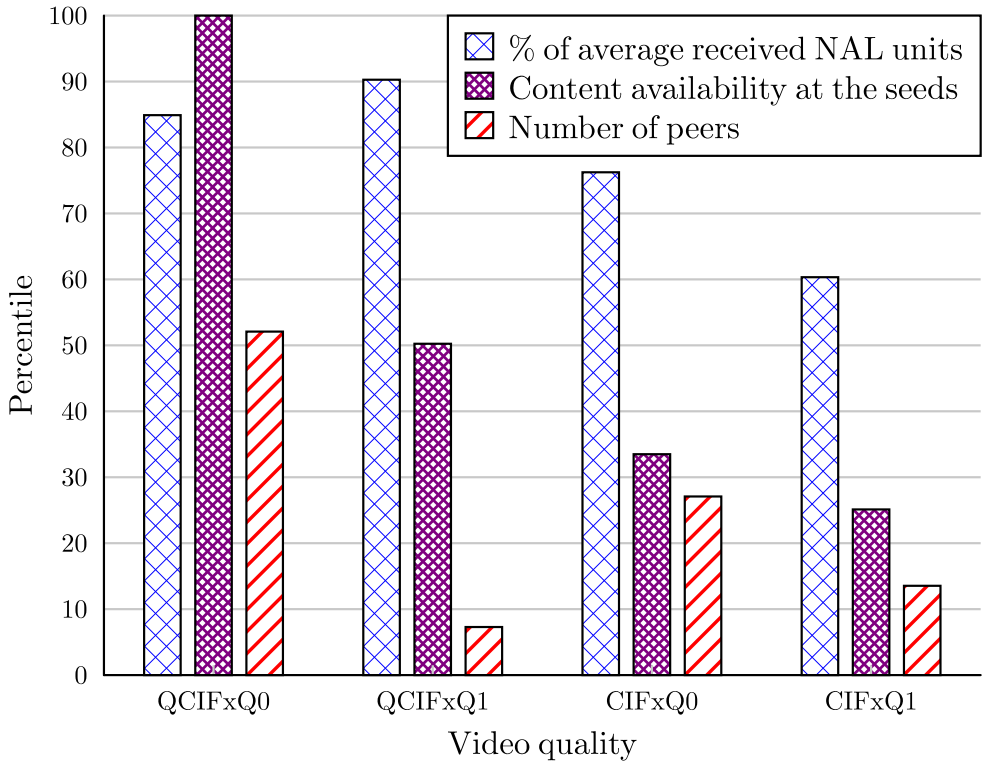


Cumulative distribution of non-received NAL units while increasing the number of peers

Observation

Efficiency drops while increasing the number of peers in the system

What influences scalability?

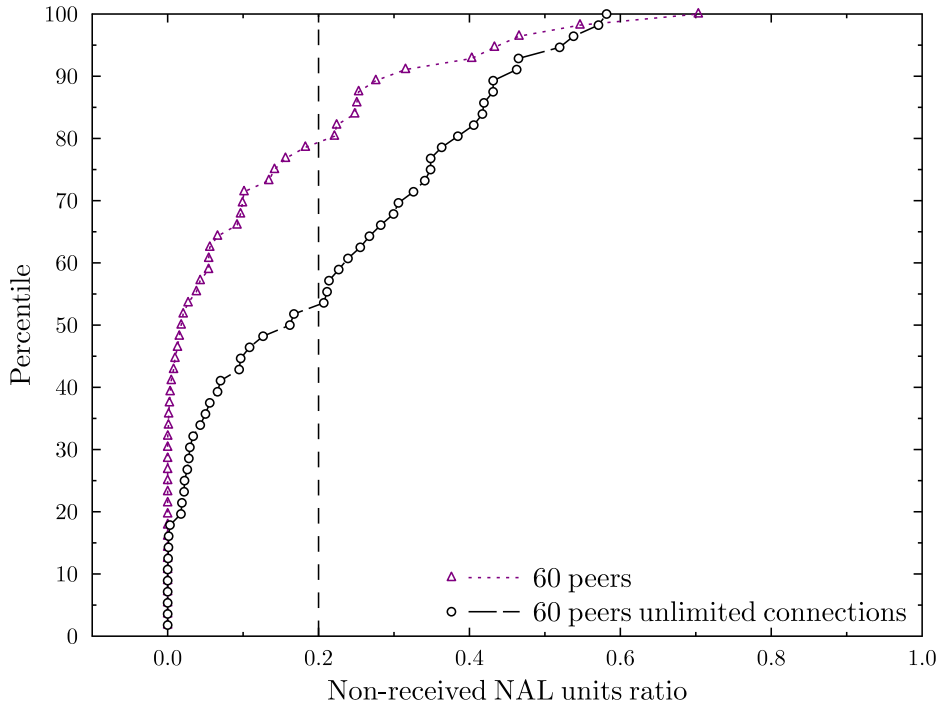


Detailed results of SVC with 4 qualities and 100 peers scenario

Observations

- Quality increases with content availability (P2P property)
- Flash crowd scenario $\Rightarrow$ Quality drops when the ratio seed/total peers is too small

Effect of the number of connections per peer



Distribution of 60 peers according to the amount of non-received data

Why this drop in performance?

Mostly due to **HAVE messages**, sent every received NAL unit to all peers
$\Rightarrow$ creating too much traffic

Conclusion

Summary

- We proposed a solution to the problem of video streaming over Internet.
- SVC provides means for stream adaptation and increases the global utility of the content
- Overlay reorganization was necessary to achieve a high Quality of Service (QoS) for the clients

Future work

- Use a more realistic topology (Georgia Tech Internet Topology Model [12])
- Comparison to other distributed and adaptive video streaming solutions
- This work can be extended with Multiple Description Coding or Network Coding

Q & A ?

Thank you for your attention

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